Ioannis Stavrakakis
Michael Smirnov (Eds.)

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Autonomic Communication

Second International IFIP Workshop, WAC 2005
Athens, Greece, October 2005
Revised Selected Papers

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Preface

The Second IFIP Workshop on Autonomic Communication (WAC 2005) took place on October 2–5, 2005, in Athens, Greece. The previous (and first) edition of WAC took place in Berlin in 2004 and its next (and third) edition in Paris in 2006. The workshop was organized by the National and Kapodistrian University of Athens and was supported by the EU-funded IST-FET Autonomic Communication Coordination Action (ACCA – IST-6475). Additional support was provided by the EU-funded IST Network of Excellence E-NEXT (IST-506869). Finally, IFIP TC6 provided scientific sponsorship through Working Groups IFIP WG6.6 (Management of Networks and Distributed Systems) and IFIP WG6.3 (Performance of Communication Systems).

The workshop was organized at a time when the – yet to be well defined – field of autonomic communication (AC) is attracting the interest of both the scientific community and the research funding organizations. The latter is manifested, on one hand, by the numerous recent relevant research exploratory forums, workshop panels, preliminary forward-looking position papers, research outlooks and frameworks and, on the other hand, by the commitment of the FET program of the European Commission in Europe to funding long-term research in this area for the next four years. Consequently, the second edition of WAC was highly exploratory and included a nice mix of technical work addressing some already identified problems and well-articulated ideas on the direction this field should take and the fundamental problems whose solution would enable autonomicity.

For a relatively new – and not yet established – workshop series that also focuses on an immature field, it is important that every effort is put into securing and establishing its quality. For this reason, the Technical Program Committee (TPC), the paper evaluation process and the overall program were all carefully set up. The 35-member TPC included predominately highly regarded, established researchers, with a few highly recommended and trusted younger and promising researchers with quality record. The TPC members were asked to review from two to five papers, depending on the thematic area, the amount of work affordable by the reviewer at the time and the desire to identify (through re-assignments) the most appropriate reviewer. The TPC co-chairs did not formally review any paper, but read some of them as needed and took care of the paper selection process. All papers received at least three reviews, and some papers received four reviews. The review scores were summarized in a table, containing for each paper: the scores for each of the questions asked and for each of the reviewer, numerical averages by each reviewer, names of reviewers and major comments by each reviewer. There was no pre-set cut-off threshold or number of papers to admit. Papers were classified in three groups based on the grades and the consistency of the grades and comments: (A) clearly accepted; (B) to be discussed carefully; (C) rejected. There were 13 papers in category A, 15 papers in category B and 7 in category C. Papers in category B were carefully considered, by reading the reviews carefully, reading the paper briefly and discussing extensively the paper and the reviews between the TPC co-chairs; 9 papers from this second class were accepted. All reviews were returned to the authors and the authors of the accepted papers were required to return a response document to the reviewers' comments, indicating how they took the criticisms (if any) into account in the final paper and pointing to and discussing any criticism they disagreed with. The previous step is an unusual one encountered typically in journal editorial processes (responses to the comments of the reviewers) and helped improve the quality of the papers that were finally presented at the workshop. Finally, the authors were given ample time and were requested to revise their paper after the workshop taking into consideration the feedback from the paper presentation at the workshop and any latest enhancements to their work or its presentation.

In addition to the 22 technical paper presentations (organized in 7 sessions) selected by following the aforementioned evaluation process, the program also included 1 keynote presentation, 3 invited presentations and 2 panels.

The keynote talk was delivered by Paul Spirakis (University of Patras - Research Academic Computer Technology Institute, Greece) and addressed algorithmic aspects of sensor networks with emphasis on complexity. The first invited presentation discussed research challenges on opportunistic spectrum access for wireless ad hoc networks and was delivered by Cesar Santivanez (BBN Technologies, USA). The second invited presentation discussed incentive schemes in memory-less P2P systems and was delivered by Costas Courcoubetis (Athens University of Economics and Business, Greece). The third invited presentation focused on coordination and resilience in ad hoc and sensor networks and was delivered by Leandros Tassiulas (University of Thessaly, Greece). Summaries of all the above presentations are included in these proceedings.

The first panel in WAC 2005 focused on the relation between autonomicity and complexity and discussed the extent to which autonomicity reduces management complexity and possibly increases overall (system) complexity. The panel was composed of the following researchers from academia, research organizations and the industry: Paul Spirakis of the University of Patras - Research Academic Computer Technology Institute in Greece (coordinator), Radu Popescu-Zeletin and Mikhail Smirnov of Fraunhofer FOKUS in Germany, David Lewis of Trinity College Dublin in Ireland, Tom Pfeifer of Waterford IT in Ireland, Stefan Schmid of NEC Europe in Germany and Cesar Santivanez of BBN Technologies in USA. An extended report on the deliberations and conclusions of this panel is included in this volume.

The second panel posed several interesting questions on presented ideas in an effort to discuss and define a meaningful and effective autonomic communication roadmap. The panelists were predominately researchers participating in the IST FET Autonomic Communication Coordination Action (ACCA) who have been involved in the last year or two in a European-wide effort to define and promote this research field. Specifically, these panellists were: Mikhail Smirnov of Fraunhofer FOKUS in Germany (Chair), Lidia Yamamoto of the University of Basel in Switzerland, Spyros Denazis of the University of Patras in Greece and Hitachi SAL in France, Simon Dobson of University College Dublin in Ireland, Ioannis Stavrakakis of NKUA in Greece, James Scott of Intel Corporation (UK) Ltd., David Lewis of Trinity College Dublin in Ireland, Jaouhar Ayadi of CSEM in Switzerland, and Serge Fdida of UPMC in France. In addition to the aforementioned ACCA researchers, the following speakers were invited: Fabrizio Sestini of European Commission Future and Emerging Technologies and Nancy Alonistioti of NKUA in Greece, also representing the IST integrated project E2R. An extended report on the deliberations and conclusions of this panel is included in these proceedings.

The help and contributions of several people – that made WAC 2005 possible and successful – are highly appreciated and acknowledged: the TPC members and the reviewers, the authors and presenters of the papers, the invited speakers and the panelists, as well as the officers of the Future and Emerging Technologies (FET) Program European Commission, the researchers of the EU-funded IST-FET Autonomic Communication Coordination Action (ACCA), the EU-funded IST Network of Excellence E-NEXT, the Autonomic Communication Forum (ACF), IFIP TC6 and all the individuals involved from the National and Kapodistrian University of Athens.

December 2005

Ioannis Stavrakakis
Michael Smirnov

About This Book

This is the post-workshop proceedings of the Second IFIP TC6 WG6.3 and WG6.6 International Workshop on Autonomic Communication (WAC2 2005); it includes 22 full papers presented at WAC 2005 and revised by the authors based on the workshop discussions, and summaries of the one keynote talk and three invited talks and two panel reports.

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Invited Program

Panel Reports

Pocket Switched Networking: Challenges, Feasibility and Implementation Issues

Pan Hui[1], Augustin Chaintreau[2], Richard Gass[2], James Scott[2], Jon Crowcroft[1], and Christophe Diot[2]

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Abstract. The Internet is built around the assumption of contemporaneous end-to-end connectivity. This is at odds with what typically happens in mobile networking, where mobile devices move between islands of connectivity, having opportunity to transmit packets through their wireless interface or simply carrying the data toward a connectivity island. We propose *Pocket Switched Networking*, a communication paradigm which reflects the reality faced by the mobile user. Pocket Networking falls under DTN. We describe the challenges that this approach entails and provide evidence that it is feasible with today's technology.

1 Introduction

Mobile networking is finally becoming ubiquitously deployed, due in large part to the convergence of mobile telephony and handheld computing. Current mobile devices typically have one or more wireless interfaces (e.g. Bluetooth, WiFi). The applications which are commonly deployed on such devices (e.g. email, web browsing), however, are rarely able to fully exploit this local wireless connectivity, and instead use it only as a means of acquiring global connectivity via access points.

Therefore, there is currently a large amount of wireless bandwidth capacity that remains unused because the current communication paradigm (i.e. the Internet) has not been designed to take advantage of local and intermittent connectivity. The underlying reason for this failure is that *IP-centric networking* (a term covering everything from the IP network layer through to application-layer protocols such as HTTP) relies on several assumptions which do not hold for mobile users. One such assumption is that the source and recipient of a datagram are *contemporaneously connected*, i.e. that throughout a communication there exists a complete path between the two parties communicating. Another assumption, based on the end-to-end argument, is that it is sensible to determine the precise endpoints of a connection before any application data is transferred, and to have intermediate nodes in the network simply perform best-effort routing.

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We propose a new set of assumptions for mobile networking. We argue that these assumptions lead to a new networking model, which we term *Pocket Switched Networking* (or PSN) since it relies on both occasional transmission opportunities and user mobility to carry data to their destination. These assumptions are as follows. Mobile networking users carry one or more devices having significant storage capacity. Their mobility may be useful as a data-carrying mechanism. Devices have local networking interfaces, with which they can exchange data with neighbors. Devices may have access to one or more global networks (e.g., Internet, GSM), which differ in price, bandwidth, and availability. Both global and local connections may provide *opportunities* to transfer data.

We identify two classes of communications that users demand. Local communication allows wireless devices to use their communication infrastructure to provide communication services in the absence of end-to-end infrastructure. Local services are currently not provided by the Internet. Examples are prevention of natural risks and disasters, security, localization, messaging. Global services extent legacy communication services such as those provided by GSM, GPRS, or the Internet. They make these legacy services available to mobile users. Note that some services can make use of both local and global communication paradigms. Examples are "ad-hoc google" and asynchronous messaging.

In the next section, we position Pocket Switched Networking with regard to related initiatives in mobile networking. We then discuss the challenges that Pocket Networking must solve, and present experiments into the feasibility of Pocket Networking.

2 Related Architectures

Pocket Switched Networking falls under Delay Tolerant Networking (DTN) umbrella. The delay Tolerant Networking research Group [1] defines itself as follows: "The Delay-Tolerant Networking Research Group (DTNRG) is concerned with how to address the architectural and protocol design principles arising from the need to provide interoperable communications with and among extreme and performance-challenged environments where continuous end-to-end connectivity cannot be assumed. Examples of such environments include spacecraft, military/tactical, some forms of disaster response, underwater, and some forms of ad-hoc sensor/actuator networks". The Delay Tolerant Networking (DTN) architecture, routes self-contained messages ("bundles") through networks with long delays, high error links, and intermittently connected, pre-scheduled, or opportunistic link availability. DTN messages contain information about service requirements and setup, though there is little notion of using application-level information to assist in forwarding decisions. However, the DTN RG does not make the assumption that the current DTN architecture is the only one possible.

Therefore, Pocket Switched Networking is a specific application domain of DTN. However, we take a radically different approach than most of the DTN

[1] www.dtnrg.org

related work to date. Instead of trying to extend the Internet legacy applications to support intermittently connected communication environment, we choose to design a new communication architecture, orthogonal to the Internet, that can use the Internet (as any other local communication) when available.

We believe that under the PSN assumptions described above, IP-centric networking is not a sensible approach. Reasons are abundant, from the need for the sender to determine the IP address of the recipient before sending data, to the use of closed-loop protocols such as TCP, SMTP and HTTP which employ a sequence of end-to-end exchanges for data transfer. In addition, IP-centric networking often relies on the availability of infrastructure services (e.g. DNS) that are not systematically available to mobile users. We assert that most attempts in this area are designed to extend IP-centric networking to new environments, and rely on the same invalid end-to-end assumptions.

Mobile Ad-Hoc Networks (MANET)[2] attempt to utilize local bandwidth without the presence of an infrastructure provider. However, they are IP-centric and aim to provide Internet style routes. For example, protocols such as AODV [9] depend on contemporaneous connectivity between the endpoints, and do not work if the only connectivity available is asynchronous and depends on mobility of nodes. Both MANET and DTN require a sender to know the recipient address for a given communication. In PSN, such an assumption cannot be made, as the destination may be a particular node, a class of nodes, or any node able to service the request.

Some sensor networks act in an opportunistic fashion. One example is Zebranet, which uses intermittent connections between zebra-mounted nodes to transfer sensor data and collect statistics about zebra populations. This and other similar projects do not target the mobile user domain of PSN, and thus do not address challenges such as trust and usability.

There is an interesting synergy between PSN and pervasive computing [11]. Both are user-centric, and face the challenges of trust, usability, and the need to collapse layered networking models to accomplish their goals. It is our belief that PSN provides a networking abstraction which serves the needs of pervasive computing much more cleanly than IP-centric approaches.

3 Challenges

We have defined PSN as a communication paradigm capable of taking advantage of both local and global connectivity, as well as device mobility to convey messages or queries[3] to an appropriate endpoint, in the absence of contemporaneous end-to-end connectivity and global services. In this section, we identify the challenges that have to be addressed to successfully implement PSN. We outline previous attempts to address these challenges, and highlight the key problems of PSN yet to be solved.

[2] www.ietf.org/html.charters/manet-charter.html

[3] These two terms are used interchangeably to mean "transmission data units."